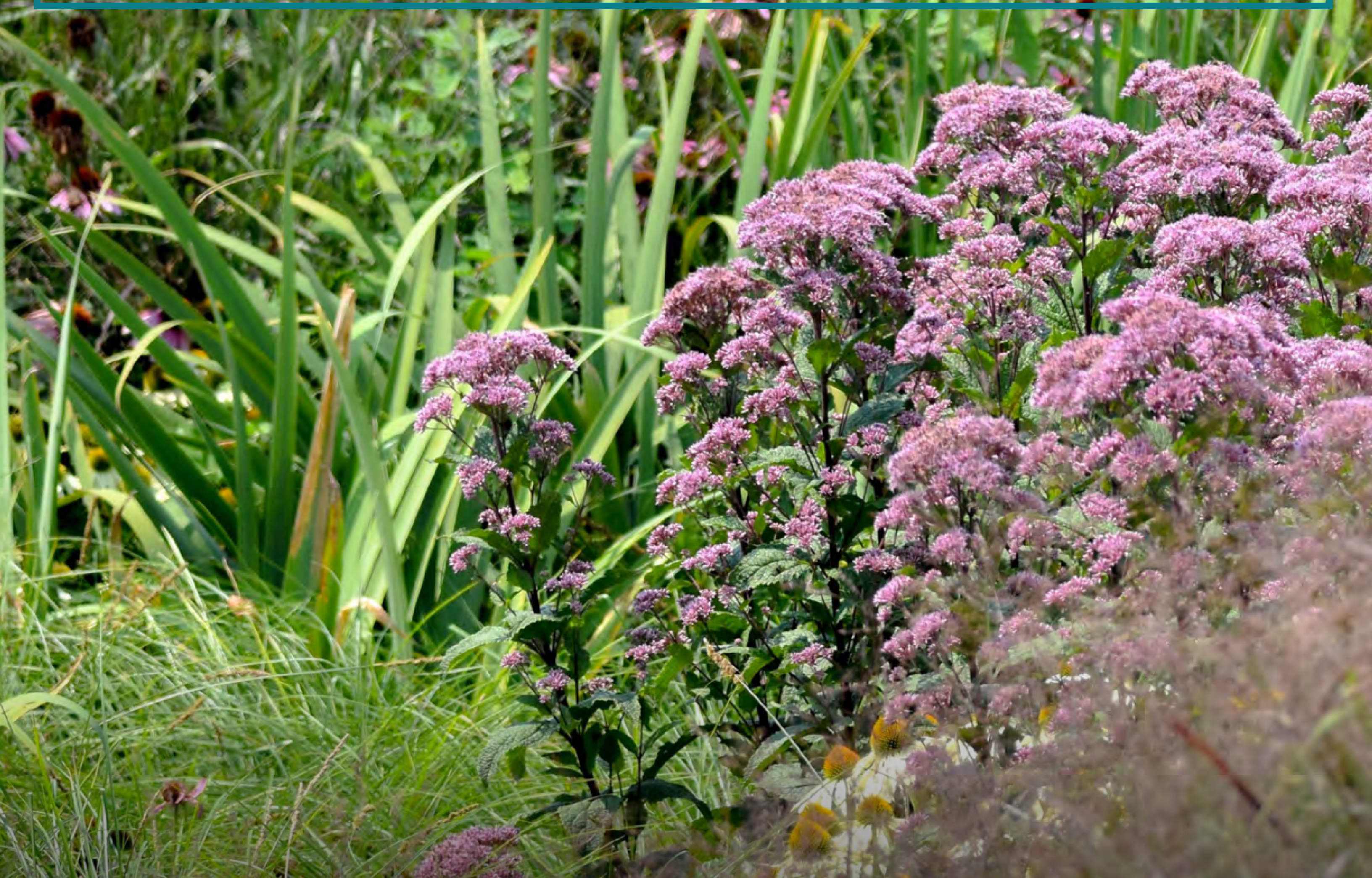
A Guide to Understanding & Quantifying the

URBAN HABITAT BENEFITS of Green Stormwater Infrastructure



GSI Impact Hub

Capturing the Multiple Benefits of Green Infrastructure

The Nature Conservancy

Green Infrastructure Leadership Exchange

One Water Econ

Credit: Matt Kane/TNC

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Introduction

Credit: Steve Weinik

INTRODUCTION

Many green stormwater infrastructure (GSI) practices, including rain gardens, bioretention facilities, trees, retention ponds, and wetlands, can contribute to the network of green spaces that support ecosystems and biodiversity in urban and suburban settings.

Urban and suburban green spaces – including parks, street plantings, greenways, streams, landscaping, and vacant lots – can provide important habitat and biodiversity benefits. Within the urban landscape, this network of green spaces supports healthy ecosystems by:

- Providing food and refuge for birds, amphibians, bees, butterflies, and other species.[1,2]
- Promoting functional groups of insects that enhance pollination and bird communities, which in turn enhance seed dispersal.[3]
- Providing landscape connectivity and encouraging the movement of mobile organisms between habitat patches.[4]

This is particularly true in areas where development and impervious cover have degraded habitat for native species and/or where green spaces are isolated within the built environment. GSI also provides benefits for aquatic ecosystems by improving water quality, reducing peak flows, and recharging aquifers tied to groundwater-dependent rivers and streams. Often, Clean Water Act permits and other legal or regulatory obligations serve as the drivers for GSI implementation that, in turn, provides habitat and ecosystem benefits.

With respect to habitat and biodiversity, not all GSI is created equal. The extent to which GSI provides these benefits depends on several factors, including the characteristics and needs of key species, proximity to other natural areas, design and management of the surrounding built environment, local environmental conditions, and the characteristics of individual GSI projects. However, much of the GSI-specific research on this topic is academic in nature, with limited practical guidance on appropriate ecological design principles or quantifying and valuing habitat and biodiversity benefits. The purpose of this guide is to provide information and resources to help municipal staff better understand, achieve, and account for these benefits.

This guide is organized as follows:

- **Section 2** provides an overview of findings from the literature related to the habitat and biodiversity benefits of relevant GSI practices.
- **Section 3** describes the planning and design elements necessary for achieving these benefits.
- **Section 4** highlights methodologies for quantifying and monetizing habitat improvements associated with GSI.
- **Section 5** identifies funding, financing, and partnership opportunities for GSI projects that enhance habitat and biodiversity.
- **Section 6** summarizes key takeaways and research gaps related to this co-benefit.

GSI Impact Hub

This guide is a component of the GSI Impact Hub, a larger project that provides resources and support related to specific GSI co-benefits. Please visit the GSI Impact Hub website to explore additional resources including:

- Compendium of GSI Co-benefits Valuation Resources
- GSI Impact Calculator, a block-level tool for quantifying and monetizing co-benefits
- Benefit guides related to flood risk reduction, habitat and biodiversity, heat risk reduction, and transportation.

The GSI Impact Hub is a collaboration between The Nature Conservancy, Green Infrastructure Leadership Exchange, One Water Econ, government agencies and technical partners.

Key Questions Addressed in This Guide

- What are the terrestrial and aquatic habitat improvements and biodiversity benefits offered by GSI projects?
- Which GSI practices provide the greatest habitat benefits?
- How can GSI be sited and designed to improve habitat and support key species?
- How can stormwater management practitioners form successful partnerships to achieve and monitor for habitat and biodiversity benefits?
- How can we value and monetize the habitat benefits of GSI projects?
- What are available funding sources for new GSI projects with habitat benefits?

Credit: Green Infrastructure Leadership Exchange

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Overview of GSI Habitat and Biodiversity Benefits

Credit: Matthew McDaniel

OVERVIEW OF GSI HABITAT AND BIODIVERSITY BENEFITS

GSI practices such as rain gardens, green roofs, urban gardens, bioretention facilities, and trees can enhance terrestrial urban ecosystems by creating new habitat, improving the quality of existing habitat, and providing connectivity to larger-scale habitat areas.

Over the past one hundred years, the continental United States has lost more than 150 million acres of habitat to urbanization and sprawl.[5] In many cases, the fragments of habitat that remain are not substantial enough, or of sufficient quality, to sustain biodiversity or support key species. As an example, the United States Department of Agriculture (USDA) cites habitat loss in urban areas as a key contributing factor to the decline in pollinators that has attracted much attention in recent years.[6]

Overall, there is a small but growing body of literature investigating the habitat benefits of green roofs, with less information specific to rain gardens, bioretention facilities, and other GSI interventions.[7] While research is limited, some studies have documented the potential of these various GSI practices to create or expand habitat, especially for arthropods and other pollinators (see Table 1).[8,9,10] Several have also demonstrated that strategically located ground-level GSI holds significant potential to enhance local ecosystems by providing habitat connectivity, essentially creating wildlife corridors.[11,12] Areas that provide this benefit can help to prevent local extinction, facilitate re-colonization, and maintain vital biological interactions (e.g., plant-pollinator interactions and plant-seed dispersal).[13]

While several studies have documented the role of green roofs in enhancing urban ecosystems, others have cautioned that the habitat and biodiversity benefits of green roofs need further study, noting concerns related to limited habitat area and quality, as well as opportunities for connectivity across the urban landscape. However, Green Roofs for Healthy Cities cites several real-world examples of green roofs that have demonstrated significant habitat and biodiversity benefits through intentional design,[14] including the City of Vancouver Convention Center's six-acre living green roof (see text box).

Urban stormwater ponds and constructed wetlands can also provide important habitat - for both aquatic species and semi-aquatic species. These practices often have high concentrations of pollutants due to the runoff managed, which can create suboptimal aquatic habitats.[15] Despite this, several studies have found significant

Credit: arch20

Vancouver Convention Center's Living Roof Provides Important Habitat Benefits

The Vancouver Convention Center's living roof is the largest coastal meadow in the city's downtown area. Spanning six acres, it is also the largest green roof in Canada. The roof was built in 2009, and since then 250 taxa of insects have been observed on the roof, including butterflies, moths, and two species of pollinating insects that were thought to be extinct in the Vancouver area, among others. The roof is home to four beehives with approximately 240,000 bees that provide honey for the facility's kitchen, as well as a family of nesting Canadian Geese who return every year to raise their young. Researchers from the University of British Columbia are using the roof to study insects and learn more about how living roofs contribute to biodiversity in urban environments.

The roof meadow has a six-inch substrate and a nutrient management plan that supports the growth of the grass-based habitat and wildflowers native to the region. The roof is mowed once a year in the fall by a crew of six landscapers. The water used to irrigate the roof is recycled from the center's black-water treatment plant, which collects and cleans water from the venue's restrooms.

In a YouTube interview, one the roof's designers indicates that the project team saw the living roof as the start of a more comprehensive effort to link nearby habitats to downtown and through the city. An article in the Living Architecture Monitor notes that because there is an acute awareness of the potential habitat benefits of green roofs by developers, the city, and design teams, there are now more than a few outstanding grass-based living roofs in the Vancouver metro area.

Sources: Greenroofs.com, Dvorak (2022), Sturken (2019)

Table 1. Select studies exploring habitat benefits associated with vegetated GSI practices

GSI Practice	Region	Description	Results	Author
Native plants	Mid-Atlantic	Compared biodiversity (species richness and abundance) associated with native and non-native landscapes	Study confirmed the connection between native plants and suburban biodiversity, providing evidence that the landscaping choices affect populations of birds and the insect food they require.[23]	Tallamy (2009)
Rain gardens	Pennsylvania	Examined plant selection for increases in biodiversity values	Rain gardens can provide food (fruits, seeds, and nectar) and shelter for birds and other species, increasing biodiversity.[24]	Penn State Extension (2016)
Pollinator habitat	Northern Italy	Investigated aspects of pollination along urbanization gradient of landscape and climate; quantified hoverfly and bee abundances, pollen transported, and nectar at 40 sites	Pollinator abundances peaked at 22% impervious cover. Pollinators are negatively affected by a thermally harsh climate in highly urbanized areas with isolated green areas and large parks. Suburban landscapes demonstrated the highest pollinator presence. Patterns from this study served as a basis for pollinator-friendly planning, mitigation, and management of urban landscapes.[25]	Biella et al. (2021)
Urban trees	Unknown	Tracked bats daytime roosts in trees and buildings	Urban trees provided 50% of the roost sites for several species of bats, serve as hosts for flora, and provide nutrients to various levels of the food chain through leaf litter and decaying materials.[26]	Kubista and Bruckner (2015)
Green roofs	Mid-West	Counting survey on twelve green roofs over two bird breeding seasons of bird behavior	Green roofs provide feeding, breeding, and resting grounds for local and migratory birds.[27]	Eakin et al. (2015)
Green roofs	Toronto, CA	Discussion of using green roofs to promote biodiversity	Green roofs facilitate dispersal of wildlife by connecting fragmented habitats.[28]	Currie and Bass (2010)
Green roofs	Mostly Europe	Lit review of ecological and technical specificities of green walls and green roofs considering key factors concerning urban wildlife (patch size, quality, abundance, and isolation)	Role of green roofs in urban wildlife corridors remains questionable because of limited patch size, distinct habitat quality at the building scale, and limited redundancy of the patch quality within the landscape. Potential habitat and biodiversity benefits also seem to depend on building height.[29]	Mayrand and Clergeau (2018)
Retention ponds	Various	Review of publications for promoting biodiversity in urban ponds	Biodiversity of urban ponds, measured by species richness, is generally lower than in rural ponds but that urban ponds often support threatened species.[30]	Oertli and Parris (2019)
Highway ponds	Europe	Compared aquatic macroinvertebrates in highway stormwater ponds with ponds in the wider landscape	Highway ponds support aquatic macroinvertebrate communities at least as rich and diverse as surrounding ponds.[31]	Le Viol et al. (2009)
Constructed wetlands	Toronto	Investigation of a delta marsh restoration project on urbanized river	Wetland stored contaminated runoff, resulting in a concentration of toxic environments in vegetation and sediments; wetlands not suited for the dual purpose of water quality improvement and aquatic habitat enhancement.[32]	Helfield and Diamond (1997)
Wetlands		Compared macroinvertebrate populations in wetlands receiving stormwater runoff and not receiving runoff.	Water chemistry differed significantly between the two but biodiversity in the richest wetlands receiving runoff matched biodiversity in the wetlands not receiving runoff.	Hassall and Anderson (2015)

ecosystem benefits to ponds and wetlands, including increased habitat for a wide range of species (including threatened species) and connecting habitat across urban landscapes.[16,17] In addition, some studies indicate that the role of stormwater management does not significantly affect biodiversity benefits.[18,19] Table 1 summarizes several studies that have evaluated the urban habitat benefits associated with different GSI interventions.

GSI practices can also significantly benefit instream species by improving water quality, enhancing streamflow, and/or reducing unnatural peak flows or flashiness. The water quality benefits of GSI are well documented, and water quality parameters are often used as indicators for healthy streams and habitat. The City of Seattle cites a study that exposed salmon to stormwater runoff from a local highway as a key reason it has accelerated the use of GSI in regional efforts to improve water quality in Puget Sound.[20] The study concluded that stormwater pollution was lethal to salmon, as every salmon exposed to it died within 4 to 6 hours. However, when exposed to highway runoff that had been filtered through a soil mixture (similar to a GSI intervention), the salmon survived 100% of the time. As evidenced by this experience, GSI practices located, designed, and installed to address toxic hotspots can provide meaningful reductions in pollutant loadings that adversely impact local species and ecosystems.

There is less understanding of how GSI affects watershed-scale hydrology, including instream flows. Flow and dimensions of flow (i.e., magnitude, frequency, duration, timing) directly affect instream biodiversity because many aquatic organisms depend on flow for feeding, reproduction, and movement. Flow also influences water quality, food supply, physical habitat, and biological interactions.[21] In a recent study, Conley et al. (2022) examined the relationship between urban greening and downstream hydrologic conditions, finding that on average, a 10% increase in "greenness" resulted in corresponding reductions in total flow (–3.8%), peak flows (–4.7%), and high flows (–7.6%), among other variables; and a corresponding increase in baseflow (4.3%).[22]

Why do we care about pollinators and arthropods?

Pollinators like birds, bats, bees, butterflies, beetles, and other small insects, travel from plant to plant carrying pollen on their bodies and facilitating the transfer of genetic material that is critical to the reproductive system of most flowering plants. Approximately 75% of the world's flowering plants and about 35% percent of the world's food crops depend on animal pollinators to reproduce. Pollinators also support healthy ecosystems that clean the air, stabilize soils, protect from severe weather, and support other wildlife. Across the world, pollinator populations are in decline due to a loss in feeding and nesting habitats. Pollution, the misuse of chemicals, disease, and changes in climatic patterns are also contributing to shrinking pollinator populations.

Arthropods are invertebrates with jointed legs – including spiders, mites, insects, centipedes, ants, and millipedes. They make up about 75% of all animals on Earth and have a major role in maintaining ecosystems as pollinators, recyclers of nutrients, scavengers, and food for birds, fish, and mammals.

Sources: Pollinator partnership, USDA (2022)

While the authors were focused on hydrology rather than the associated benefits for instream habitat, their findings indicate the potential for instream habitat benefits associated with increased GSI based on hydrologic improvements.

A study reporting results from 20 years of monitoring the effectiveness of stormwater management controls in Montgomery County, MD highlighted findings related to the effect of distributed practices on flow regimes and associated impacts on habitat and species.

Credit: Matt Kane/TNC

Comparing three treatment watersheds to a reference (forested) watershed and an urban control watershed with centralized detention facilities, researchers found that distributed stormwater management can mitigate changes to streamflow and, in some cases replicate reference conditions. The authors report that at both the street and watershed scale, runoff yield and peak flows were lower in the treatment watersheds than in the urban control watershed up to a certain level of precipitation (e.g., at the street scale, a green street yielded much less runoff than a traditional curb and gutter street up to 20 mm precipitation depth, while peak flows from the green street were less in all but the most extreme events). As precipitation depth increased, the treatment watersheds produced runoff yields and peak flows similar to the urban control watershed. However, the authors note that mitigating small and moderate precipitation events with distributed stormwater management reduces the frequency of flow perturbations that affect aquatic species in urban streams, allowing more time for benthic recovery after flow disturbances.[33]

3 Planning and Designing GSI for Urban Habitat and Biodiversity Benefits

Credit: Rick Triana

PLANNING AND DESIGNING GSI FOR URBAN HABITAT AND BIODIVERSITY BENEFITS

The habitat and biodiversity benefits of GSI can be maximized by selecting practices that consider the needs of target species and the connectivity of the site to the broader landscape.

While the primary purpose of GSI installations is to reduce runoff volumes and/or improve water quality, there are several strategies that stormwater managers can employ to optimize the "biodiversity friendliness" of GSI design and management.[34] Multiple factors influence the ability of GSI to provide these benefits, including:

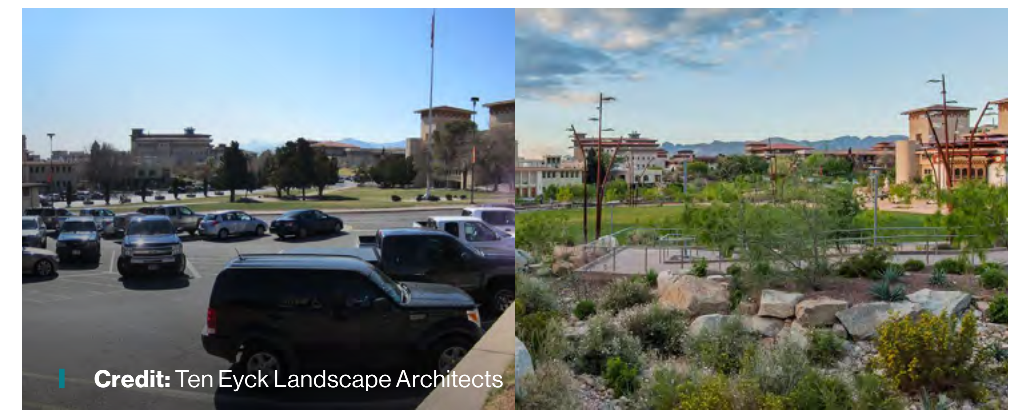
- Landscape scale considerations (e.g., design and management of the surrounding environment and proximity to other natural areas)
- Characteristics of target species (e.g., distance traveled for seed dispersal, habitat size requirements)
- Characteristics and design of individual GSI practices (e.g., type and diversity of vegetation)
- Management and maintenance over time.

The following sections discuss these factors and highlight best practices to consider during planning. As with all co-benefits, these factors and design elements (and associated tradeoffs) should be considered within the context of overall project or program objectives.

3.1 Integrating GSI into urban landscapes

To maximize habitat and biodiversity benefits, GSI planning should occur at the landscape scale when possible, identifying areas where projects can create critical habitat for priority species. This requires an understanding of surrounding land uses, existing habitat areas, and target species requirements. For example, isolated GSI interventions will have limited value to biodiversity if organisms are unable to disperse to and from the habitat; however, if strategically placed near existing habitat patches or corridors, the same intervention can increase available habitat or provide important connectivity benefits.[35] The area required by species for certain activities will also influence the selection of potential project sites. Once identified, these areas can be cross referenced with locations that have been identified as high priority for stormwater management or other program goals, such as reducing Total Maximum Daily Loads or Combined Sewer Overflows, treating infiltration and inflow, or maximizing other co-benefits.[36] While establishing GSI connectivity across multiple practices and at landscape scale may provide optimal benefit, in cases where this is not yet possible, initial GSI projects can set the stage for future connectivity as implementation rates extend over times. At the general site level, consider climate factors such as available water supplies, frequency of flooding, and sun exposure, all of which can affect growth conditions and habitat suitability. Human uses surrounding the project area also matter. For example, the Sierra Club indicates that pet encroachment, noise, and light pollution can all have adverse effects on the use of habitat for different species and lifecycle phases (e.g., nesting).[37]

GSI provides habitat in an arid environment.



Credit: Ten Eyck Landscape Architects

University of Texas El Paso Campus Transformation Plan: Designing for Native Landscapes

In 2012, the University of Texas at El Paso embarked on a project to transform their campus to better manage stormwater and use native species. The campus terrain includes hills, mountains, and arroyos (irrigation channels) that channel water from the mountains down to the surrounding plains. Over time, many of these arroyos had been paved over to create roads and parking lots. Invasive plants had become prevalent. The University president, Diana Natalicio, had a vision for a pedestrian-friendly campus that reincorporated the arroyos and native landscapes.

The redesigned campus was finished in 2015 at an estimated cost of $22 million. The design included reconstructed arroyos and retention ponds that catch, direct, and treat stormwater. Native species that thrive in the region's climate extremes of drought and ephemeral flooding including desert willow, native grasses, mesquites, acacias, mountain laurels, and oaks replaced invasive species. Fragrant native flowering species attract pollinators and birds. Permeable surfaces replaced pavement. The project earned the first Sustainable SITES Initiative Silver Certification, a certification akin to LEED certification for landscapes.

Sources: Ten Eyck Landscape Architects (2023), Infanzon, N. (2016), Rentería, R. (2015), Jacques (2016)

Credit: Matt Kane/TNC

In general, factors to consider when assessing the context of your project location include:

- Opportunities to link or expand existing habitat corridors
- Areas that are also high priority for stormwater management
- Size of the project area
- Intended use of the project area
- Sun exposure and intensity
- Water availability and frequency of floods

Even if the project location is already fixed, design considerations can maximize habitat benefits. In general, a diversity of species, vegetative structures, and substrates benefit biodiversity. Some things to consider include prioritizing native plant species that will help support pollinators, birds, and other target species; creating opportunities for wildlife to hide from predators in wood or rock crevices; and providing conditions for a replenishing water and food supply. Projects can also include flowering plants that bloom at various times of the year to support more species.[38] In some cases, non-native plantings may also be appropriate. This concept of "novel ecosystems" recognizes that urban environments significantly alter landscapes and that functional communities do not necessarily reflect what was historically present.[39] In addition to ground level planting, the vertical structure and density of trees and shrubs also matters, as does interaction with the nearby built environment. For example, the Sierra Club recommends strategically placing vegetation to minimize collision risk with buildings as part of its bird safe landscape design. Additional interventions such as nest boxes, bird feeders, water features, or bird baths can also be incorporated into the site.

It is important to note that urban wildlife management is complex and does not typically fall within the purview of stormwater managers. Partnering with local experts is therefore key. This can be as simple as working with landscape architects or ecologists who specialize in native habitats or taking on more comprehensive efforts, in partnership with government or non-profit agencies, to incorporate GSI into larger scale urban habitat plans. Potential partners include government agencies such as the USDA and local Soil and Water or Resource Conservation Districts (SWCDs or RCDs) and non-profit organizations (e.g., National Wildlife Federation's Wildlife Habitat Certification Program). Crowd sourcing platforms like iNaturalist or Audubon's Native Plants Database, or resources from the Pollinator Partnership can also provide valuable information.[40] Section 5 provides additional examples of partnership opportunities.

Some stormwater agencies have intentionally integrated habitat planning into GSI design. In 2018, the Milwaukee Metropolitan Sewerage District (MMSD) undertook a comprehensive effort to evaluate the potential for its' GSI program to support regional biodiversity efforts. MMSD conducted a baseline biodiversity assessment, reviewed available literature to better understand the ability of various GSI strategies to provide biodiversity benefits, and identified approaches for better realizing these benefits through strategic GSI application. The text box below summarizes MMSD's lessons learned and recommendations for enhancing urban habitat and biodiversity benefits through GSI implementation.

Framework for Planning, Designing, and Managing GSI to Achieve Habitat and Biodiversity Benefits

1. **Prioritize GSI strategies that provide habitat/biodiversity benefits.** Determine the relative value of individual GSI strategies in terms of biodiversity and other triple bottom line (TBL) benefits.
2. **Identify locations where GSI is likely to best promote urban biodiversity and improve habitat for priority species** (i.e., areas where GSI might be able to help expand and connect existing wildlife corridors and natural areas). Cross-reference for overlap with areas that are high priority for stormwater management.
3. **Partner with relevant agencies/organizations and experts to identify priority or desired species and cross-reference this list with species that are likely to benefit from the types of habitat provided by GSI practices.** For each species, identify habitat needs such as minimum habitat size/patch areas, colonization distance and height requirements, and other relevant factors.
4. **Incorporate relevant design criteria into GSI planning and design guidelines.** For example, provide guidance for maximizing structure and complexity of plants and physical habitat in GSI design (e.g., include diverse native species, flowering plants that bloom at various times of year) and for prioritizing projects that provide connectivity benefits.
5. **Look for partners and opportunities to incorporate GSI into other ongoing activities** to improve biodiversity within the region (e.g., potential opportunities to integrate GSI into planned restoration projects or other initiatives).
6. **Engage with the public to raise awareness** about 1) urban biodiversity and its importance to the region; 2) existing programs and activities they can implement to improve and protect urban biodiversity.
7. **Engage with local and statewide programs already conducting regional monitoring** of both aquatic and terrestrial systems to produce data that can be used to assess regional improvement. Engage with these programs to inform them of ongoing GSI projects as they are implemented so the cumulative density of practices on the watershed scale can be related to regional measures of diversity.

Source: MMSD (2018)

3.2 Design considerations by practice type

Although most GSI practices can offer some habitat benefits, some are more effective than others. Figure 1 shows how the Milwaukee Metropolitan Sewerage District (MMSD)[41] rated the habitat and biodiversity benefits of GSI practices as part of an effort to prioritize these benefits in GSI planning. MMSD also identified the ability of various practices to result in additional economic, social, and environmental benefits (so called triple bottom line or TBL benefits), such as improved water and air quality, increased groundwater recharge, carbon and heat island reduction, avoided gray infrastructure costs, and enhanced neighborhood aesthetics (among others), in order to provide a more holistic assessment. The list is based on existing reports, peer-reviewed literature, best practices, and professional judgment. MMSD compiled this rating for the Milwaukee area so the same rating may not apply to every context. However, it demonstrates an approach and process for thinking through the habitat and biodiversity benefits of different GSI practices.

Key design elements significantly affect the ability of GSI practices to support habitat and biodiversity. The following sections highlight site-level considerations for maximizing habitat benefits for specific GSI practices, including urban ponds and wetlands, green roofs, and others, based on a review of relevant literature.

3.2.1. Urban ponds and wetlands

Ponds and wetlands provide complex aquatic habitats and host a wide range of species, including amphibians, birds, fish, and aquatic macroinvertebrates (e.g., mollusks and insects). The types of habitats that can thrive in urban ponds and wetlands depend on multiple factors. Regional factors include proximity to major transportation corridors, impervious surfaces, buildings, or large treated turf areas. Locations close to these conditions are likely to carry heavy metal and nutrient loads, which will affect the design and type of plants the project can support. Water quality is a critical component to the efficacy of ponds and wetlands to support habitats. Project sites with higher nutrient loads are ideal for native plants or animals that can survive, or even filter out, nutrients.

The project's proximity to other ponds, wetlands, or natural green spaces is also important to consider; projects close to other areas are more likely to benefit from cross-pollination and species interaction. Species availability will play a role in the ability of a pond or wetland to contribute to biodiversity. An urban area with a variety of ponds and wetlands can support broader biodiversity. At the city scale, the biodiversity of a pond-scape benefits from a high diversity of pond types, differing in their environmental characteristics and management.[43]

Key design elements including surface area, depth, bank slope, shoreline consistency, and the availability of shade will influence the efficacy of the GSI project to create and maintain habitat for different types of species. One study found that in addition to water quality, size and the coverage of aquatic plants were the most important factors governing the species richness, abundance, and diversity in urban wetlands. However, the factors influencing community structures vary among different taxonomic groups.

Ponds constitute favorable environments for invasive species because they are typically nutrient rich with vegetation cover; however, this can be mitigated through proper management.

Figure 1. MMSD's relative ratings for benefits provided by GSI strategies[42]

Urban agriculture is not one of MMSD's GI strategies but this plan assessed this activity for its biodiversity benefits.

Land Cover Type	Overall Rating (Biodiversity + TBL)	Biodiversity Rating
Native Landscaping (tallgrass prairie plants)	High	High
Bioretention/Bioswales	High	High
Rain Gardens	High	High
Wetlands	High	High
Greenways	High	High
Urban Agriculture	High	High
Stormwater Trees	High	High
Green Roofs	High	Medium
Green Alleys, Streets, and Parking Lots	Medium	Medium
Soil Amendments	Medium	Medium
Porous Pavement	Medium	Low
Rainwater Catchment	Low/Medium	Low

Urban Pond and Wetland Habitat Design Considerations

Location and design parameters contribute to the species diversity, abundance, and ecosystem health of ponds and wetlands. Factors to consider include:

Wetland or pond location

- proximity to major roadways, treated turf, impervious surfaces
- presence and diversity of other wetlands or green spaces

Water quality

- presence of nutrients and heavy metals
- composition of riparian areas and diffusion of nutrients and metals through those areas
- native plants or animals that can survive, or filter out, nutrients of concern

Design considerations

- vegetated coverage
- depth
- bank slope
- shoreline uniformity
- shade availability

Needs of native species

- aquatic plant (macrophyte) species
- macroinvertebrates
- fish
- birds
- mammals and other species

3.2.2. Green roofs

Intentional green roof siting and design can support a diversity of insects - especially pollinators – and spiders, which can in turn support a network of secondary consumers.[44] Green roofs are more effective when surrounded by other green roofs and natural green spaces, not including turf. Green roofs on taller buildings appear to be less effective at supporting biodiversity, bee nesting, and bat activity than roofs on shorter buildings.

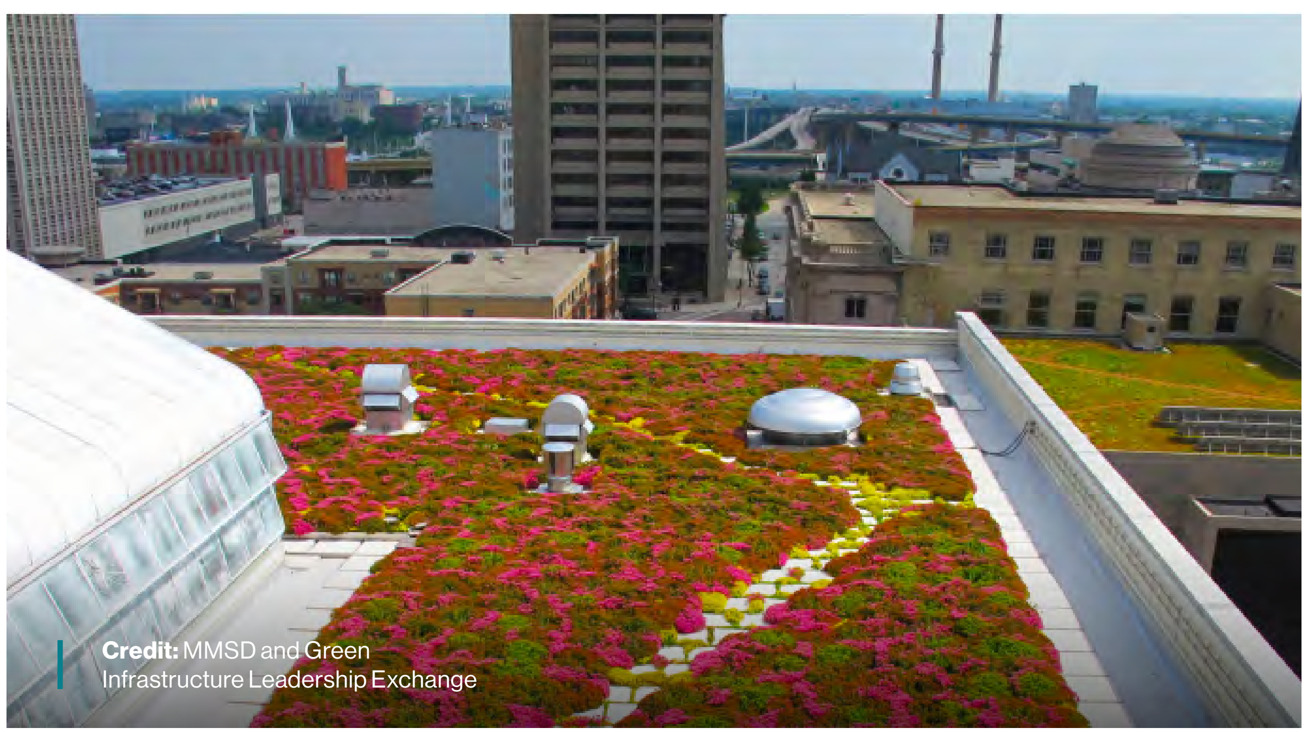
The design of the roof can also influence a roof's ability to support habitat diversity. A deeper and richer substrate will support broader and more complex plant diversity. Selecting native and blooming plants also generally helps to support greater biodiversity. Green Roof for Healthy Cities notes that grass-based ecosystems support many species of birds, bees, butterflies, beetles, and other beneficial insects, and that grass-based living roofs can be designed to support their needs (see the Vancouver Convention Center Living Roof highlighted on p. 11). A study of 115 green roof sites found that in addition to substrate depth and building height, biodiversity varies significantly based on green roof age, surface area, and maintenance intensity.[45]

As with some other practices, there can be conflicting goals for seed mixtures on green roofs. In particular, the rapidly filling vegetation canopy often required by engineering, or for aesthetics, can conflict with the preference for nondominant species to enhance species diversity.[46]

Green Roof Habitat Design Considerations

Location and design parameters contribute to the species diversity, abundance, and ecosystem health of green roofs. Factors to consider include:

- ✓ Proximity to other green spaces (potential for ground level interaction) and green roofs
- ✓ Building height
- ✓ Substrate material and depth
- ✓ Plant diversity and structure
- ✓ Surface area
- ✓ Maintenance intensity



Credit: MMSD and Green Infrastructure Leadership Exchange

Credit: Rick McEwan

3.2.3. Other practices

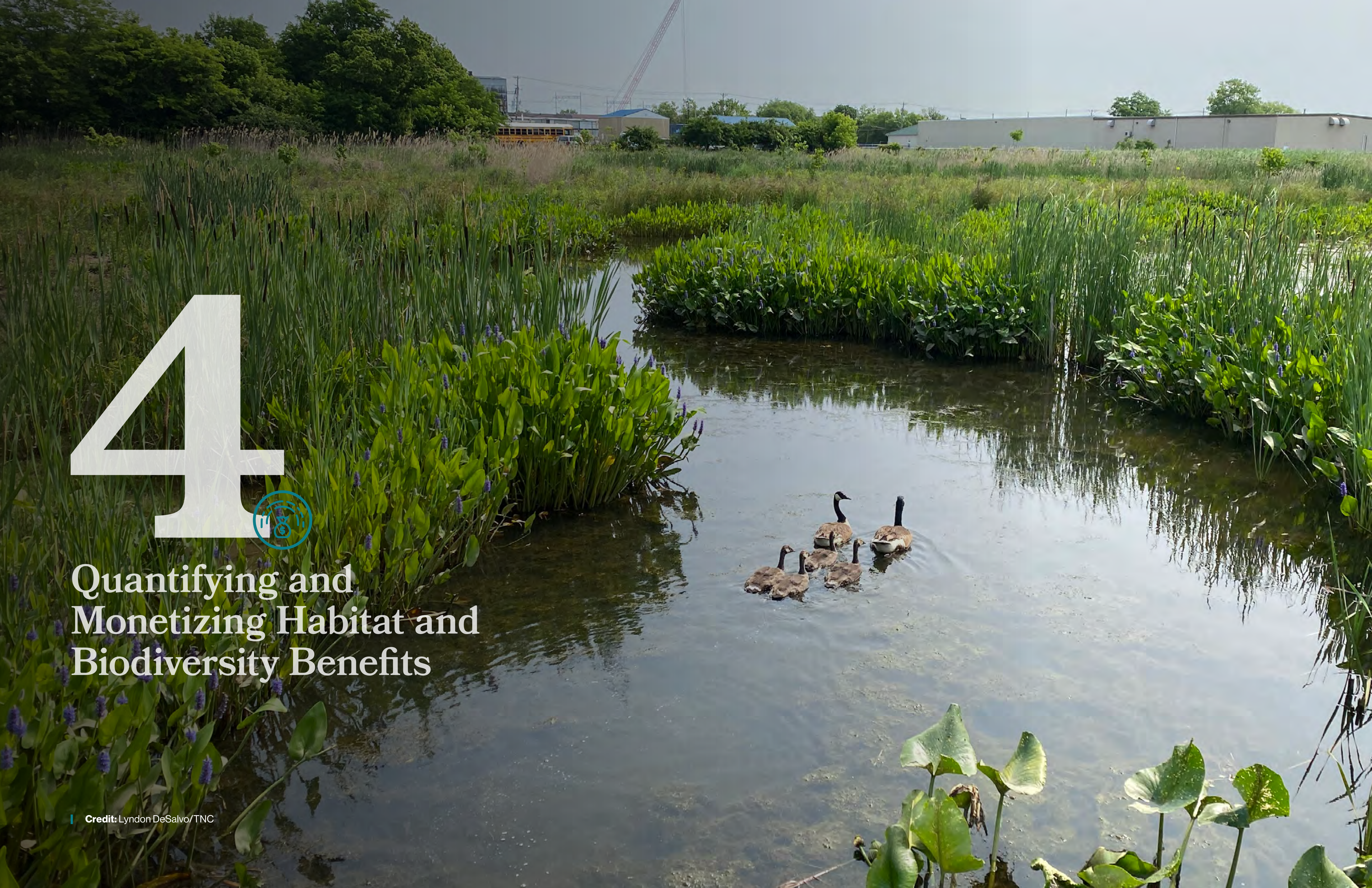
Other GSI practices, such as urban gardens, rain gardens, bioretention, and tree planting can also support habitat and biodiversity. Larger bioretention basins with more leaf litter, vegetation structure, and number of flowering plants support more insect diversity than other basins.[47] According to one study, the size of urban gardens did not influence the diversity or abundance of species.[48] This indicates a potential significant role for smaller GSI interventions. Trees play an important role in urban biodiversity by providing food, habitat, protection, and landscape connectivity for urban fauna, including small animals, birds, and insects. In its review of literature on the biodiversity benefits of GSI, MMSD (2018) found that the type and size of trees influence the level of benefits realized. Native trees and larger tree species support higher diversities and abundance of insect and bird species compared with non-native and smaller urban trees. However, a diversity of tree sizes is important for supporting different types of species.[49]

3.3 Maintaining GSI for habitat and biodiversity benefits

GSI practices change and grow over time, which can affect the provision of habitat-related benefits. Because plant communities can become quite different from the initial plantings, long-term effects should be considered (including any adverse effects associated with successional habitats). Practices should also be monitored and managed for invasive species.

Applying disturbances to an ecosystem can also affect its structure and function. Interventions such as mowing or inserting deadwood or different soil substrates can benefit biodiversity by reducing unwanted species or by increasing the number and variety of target species. Some interventions may be necessary during establishment periods - one study found that the incorporation of woody debris on newly built green roofs helped to maintain favorable conditions during stressful periods in the initial years by enhancing perennial recruitment.[50]

GSI practices should be monitored to assess whether habitat and biodiversity goals are being met. Key indicators include biomass measurements and number and abundance of species, which are not metrics typically collected by stormwater agencies. Pre- and post-project monitoring efforts can be enhanced through strategic partnerships with universities or organizations that can provide training or integrate GSI installations into ongoing monitoring efforts.



4

Quantifying and Monetizing Habitat and Biodiversity Benefits

Credit: Lyndon DeSalvo/TNC

QUANTIFYING AND MONETIZING HABITAT AND BIODIVERSITY BENEFITS

Existing methods and tools make it possible to estimate the habitat and biodiversity values of GSI.

The value of habitat improvements can be difficult to quantify. Economists have developed several methods for valuing "non-market" goods and services, including habitat for various species and improvements in water quality that benefit aquatic species. For example, stated preference methods use advanced survey techniques to elicit estimates of willingness-to-pay (WTP) for specified improvements in - or avoided degradation of - habitat or water quality, based on the species affected, nature of the improvements, and other local factors. Units are typically in terms of WTP per household or totaled to produce total WTP per acre of habitat. These methods are intended to measure the intrinsic value that individuals place on environmental goods and services.

As discussed in more detail below, other studies have estimated the value of ecosystem services supported by habitat and biodiversity improvements. For example, a recent study conducted by the University of Pennsylvania estimated that the economic value of insect pollination in the U.S. totaled $34 billion in 2012 (the year for which comprehensive data was most recently available).[51] A portion of this value can be directly attributed to pollinator habitat.

While several studies have estimated WTP values for values for urban habitat improvements in different contexts, very few have focused on the types of habitat improvements associated with GSI interventions. The following sections describe methods and tools that demonstrate the value that residents place on habitat and biodiversity in urban settings, including how some methods may be applied to estimate the value of GSI improvements in this context.

4.1 Willingness-to-pay estimates from existing studies

WTP studies that shed light on the value that people and communities place on habitat conservation or creation are often narrow in scope and highly specific to a location and specific habitat type. This makes it challenging to draw universal conclusions regarding the monetized value of habitat improvements. However, knowing the range of WTP values for a variety of characteristics of habitat can help provide upper and lower bounds to estimates in communities that have not been directly studied.

Table 2. Summary of WTP for terrestrial and aquatic habitat improvements

Note: Values are not directly comparable as they relate to different levels of improvements, different habitat and species types, and were conducted in different locations.

Metric	Region	Description	WTP (2022$)*	Author (Year)
Annual household WTP for water clarity, aquatic habitat, and fishery benefits	Chesapeake Bay	Average value per resident of Chesapeake Bay watershed	$198 per household per year	Moore et al. (2018)[52]
Annual marginal per acre value for habitat provision benefits of wetlands	Various U.S.	Meta analysis of 39 wetland valuation studies in urban and rural settings	Mean value of $1,014 per acre per year	Woodward and Wui (2001)[53]
Annual household WTP for watershed preservation	South Central U.S. Watershed	WTP survey for preservation of watershed that is water stressed and experiencing intense sociopolitical conflict	$339 per household per year total, $25.44 specifically for species habitat	Castro et al. (2016)[54]
Annual household WTP for habitat and biodiversity	Platte River, CO	Survey of households regarding WTP for ecosystem benefits associated with instream flow and riparian restoration through a higher water bill	$442 per household per year	Richardson et al. (2009)[55]
Marginal WTP per acre of pollinator habitat improvement	Ohio river basin	Choice experiment survey to estimate values for different co-benefits incorporated into water quality projects; associated with projects sold in the form of credits in a water quality market	$66.33 per acre per "conservation buyer" reflects a market price, rather than a total across individuals who value this service.	Liu and Swallow (2016)[56]
Annual household WTP for local coho salmon enhancement	Oregon and Washington	Survey of households to gauge WTP for high and low coho enhancement programs.	$33 - $194 per household per year depending on location, income, enhancement scenario.	Bell et al. (2003)[57]

Table 2 provides examples of studies that developed WTP values for terrestrial or aquatic habitat improvements. These studies estimate WTP through statistical techniques that control for various factors including income and other socioeconomic characteristics of survey respondents. Applying WTP estimates from rigorous studies in one area to a similar improvement or habitat benefit in another area is known as benefits transfer.

4.2 Tools and methods for quantifying and monetizing habitat benefits

A few tools have been developed by reputable research organizations to help practitioners quantify and monetize the benefits of habitat creation from GSI installations at a high level. The following sections provide an overview of these tools and the methodology upon which they are based.

4.2.1 Water Research Foundation (WRF) GSI TBL Tool

WRF created an empirically-based Excel tool that allows users to estimate terrestrial habitat benefits associated with GSI projects. The GSI TBL Tool calculates the total area of GSI practices that have the potential to provide habitat value based on the user's GSI scenario. The Tool then allows the user to apply an adjustment factor to account for the percentage of GSI area that will likely provide habitat value. These inputs provide the user with an estimate of total habitat area by practice type.

University of Minnesota Bee Squad Raingarden Beneficial Insects Program

The University of Minnesota's Bee Squad program provides outreach and education to beekeepers and the public about creating habitat for pollinators. The paid staff offer creative community programming where they partner with non-traditional partners to improve bee habitat and offer educational opportunities. The program encourages stormwater engineers to reach out to the Bee Squad to help them design habitats for pollinators.

One of the Bee Squad's programs is conducting a Raingarden Insect Survey in partnership with the Minnehaha Creek Watershed District. This is a joint project between stormwater managers and insect experts that has been awarded multiple grants. One of the projects' goals is to conduct public outreach and education about the importance of GSI projects and native plant and animal species. To do this they have identified youth ambassadors that are paid to conduct outreach programs and aid in bee research. This innovative collaboration has secured funding from grants, the Target Foundation, and the MN Department of Agriculture.

Source: U.S. EPA. (2019)

Table 3. WRF GSI TBL Tool relative rankings and habitat/biodiversity values for relevant GSI practices, 2022 USD.

GSI Practice	Relative Ecosystem and Biodiversity Ranking (5-point scale)	Monetary Value ($ Per Acre Per Year)
Wetlands	5	$ 4,881
Wet ponds and trees	3	$ 2,928
Rain gardens and bioretention areas	2	$ 1,953
Green roofs	0.5 to 1.5 (extensive/intensive)	$ 976 (average)

Recognizing that not all GSI practices are considered equal in terms of ecosystem and biodiversity value, the GSI TBL Tool assigns a relative ranking to the suite of GSI practices that provide ecosystem and biodiversity benefits using a 5-point scale (based on qualitative research). Starting with wetlands, the Tool relies on a meta-analysis to estimate the marginal value of habitat benefits associated with wetlands at approximately $4,264 per acre per year.[58] The monetary values per acre per year for different GSI practices are then scaled accordingly, based on their relative ranking (shown in Table 3). This methodology provides a ballpark estimate of potential habitat and biodiversity value.

The GSI TBL Tool also allows users to estimate water quality benefits that may result in aquatic habitat improvements. This methodology relies on a meta-analysis of stated preference studies conducted in the U.S. that described water quality in terms that could be converted to a common 10-point scale (Figure 2). The result of this research is a simple equation into which users can input variables specific to their location and project to estimate household WTP per year for water quality improvements. This approach controls for factors such as household income, geographic region, and other variables. It also allows for the estimate of non-use values, reflective of the value of water quality improvements that are independent of any additional recreation or use-related benefits that the improvements would provide.

Building on this methodology, the project team estimated the average WTP per household associated with a marginal increase in water quality from a "2.7" on the water quality ladder, a level characterized as "acceptable for boating," and a "4.2", a level characterized by "satisfactory habitat for some wildlife and some common food fish," to a "5.2," which is characterized as "good fish and wildlife habitat." This exercise yielded estimates of household WTP for marginal water quality improvements that result in habitat and biodiversity benefits (Table 4). Notably, these estimates are for regional (i.e., citywide) improvements and should be scaled based on the contribution of any given GSI project to estimate total value. See the Block-Level Benefits tool that accompanies this guide for additional information.

4.2.2 FEMA Benefit Cost Analysis (BCA) Tool

Agencies applying for FEMA project funding must demonstrate the benefits and costs of their proposed projects using FEMA's Benefit Cost Analysis Toolkit. The FEMA BCA tool is an Excel-based Add-In that is publicly available for use. For certain flood mitigation actions, such as stream restoration or floodplain management, users are allowed to input ecosystem services benefits associated with their projects. The tool values ecosystem services across four categories (consistent with the widely recognized ecosystem services classification framework) and for 14 subcategories. Values taken from academic literature are applied to each subcategory by land cover type, resulting

Figure 2. Water Quality Ladder.

Source: Mitchell and Carson 1981 (Appendix II)

in dollar per acre estimates. The four ecosystem services categories and 14 subcategories include:[59]

1. **Provisioning services:** tangible goods that can be used for food, lumber, or other purposes Subcategories valued in tool: food provisioning
2. **Regulating services:** benefits obtained from natural control of ecosystem processes Subcategories valued in tool: air quality, biological control, climate regulation, hazard risk reduction, erosion control, water filtration, water supply
3. **Supporting services:** refuge and reproduction habitat to wild plants and animals Subcategories valued in tool: habitat, pollination
4. **Cultural services:** provide humans with meaningful interactions with nature Subcategories valued in tool: aesthetic value, existence value, cultural value, research and education, recreation and tourism

Table 5 shows these values for different land use types, with relevant land use types highlighted in blue. Note that the Supporting Services category most directly relates to the habitat, biodiversity, and environmental benefits targeted in this guide. Table 5 shows FEMA's total ecosystem service values for each land cover type, as well as individual values for habitat and pollination services. Rows highlighted in blue are most relevant to urban GSI practices. Note that habitat and pollination values were not estimated for all land cover types.

4.2.3 InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) Tool

Developed by the Natural Capital Project (NatCap), Urban InVEST contains a suite of models used to map and value ecosystem services associated with natural capital and nature-based infrastructure. InVEST contains several models that estimate the benefits of terrestrial habitat including a habitat quality and pollination model. This tool requires advanced understanding of subject matter, as well as generated geographic information system (GIS) raster files. Values for different habitat types are not provided in the InVEST documentation.

Table 4. WRF GSI TBL Tool relative rankings and habitat/biodiversity values for relevant GSI practices, 2022 USD.

Geographic Region	States	Household WTP for water quality improvements that result in good fish and wildlife habitat ($/year)	
		2.5 to 5.2 on Water Quality Ladder	4.2 to 5.2 on Water Quality Ladder
South	Alabama, Arkansas, Florida, Georgia, Louisiana, Maryland, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia	$ 75.53	$ 41.56
Midwest	Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, North Dakota, Ohio, South Dakota, Wisconsin	$ 110.55	$ 60.84
Other states	Alaska, Arizona, California, Colorado, Connecticut, Delaware, District of Columbia, Hawaii, Idaho, Maine, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Puerto Rico, Rhode Island, Utah, Vermont, Washington, Wyoming	$ 79.56	$ 43.79

Table 5. Ecosystem service benefits by land cover type, FEMA BCA tool (2021 USD per acre per year)

Land Cover Type	Description	Total Ecosystem Service Benefits	Habitat	Pollination
Urban green open space	80% of total cover is pervious, located in urban areas	$ 15,541	$ 5,890	$ 350
Rural green open space	80% of total cover is pervious, located in rural areas	$ 10,632	$ 2,021	$ 350
Riparian	Area with no break in vegetation cover between project and nearest flood source	$ 37,199	$ 2,547	
Coastal wetlands	Tidal wetlands or deep water habitats with continuous plant cover; tidally influenced and saline water	$ 8,955	$ 2,420	
Inland wetlands	Perennial vegetation with soil periodically saturated with fresh water	$ 8,171	$ 1,416	
Forests	Area dominated by trees >5 meters tall making up at least 20% of total vegetation cover	$ 12,589		
Coral reefs	Areas of hardened, fixed substrate or structures created by deposition of calcium carbonate by reef-building coral species. Includes both deep- and shallow-water coral species.	$ 7,120	$ 2,222	
Shellfish reefs	Areas with shellfish reefs surrounded and mixed with channels and unvegetated flats, usually intertidal zones	$ 2,757		
Beaches and dunes	Sloping zone adjacent to edge of a waterbody, consisting of unconsolidated material	$ 300,649		

5

Funding, Financing, and Partnership Opportunities

Credit: Diane Cook and Len Jenshel

FUNDING, FINANCING, AND PARTNERSHIP OPPORTUNITIES

Incorporating habitat and wildlife benefits into GSI projects can create opportunities for partnerships with biodiversity-focused stakeholders as well as open doors to non-traditional sources of funding.

This section provides a snapshot of some options available from government agencies, as well as some private funding and partnerships ideas to explore.

5.1 Federal funding

Federal agencies provide a wealth of information on funding and financing GSI opportunities. At the broadest level, Grants.gov maintains a registry of all federal grant opportunities and is always a good starting point to see current opportunities, tips, and information. At a more focused scale, the Environmental Protection Agency maintains a list of Green Infrastructure Funding Opportunities that includes opportunities resources, programs, publications, and tools available from 11 Federal agencies. The National Wildlife Federation maintains a Nature-based Funding Solutions Database, a comprehensive guide to federal funding opportunities funded by the Bipartisan Infrastructure Law and Inflation Reduction Act. Funding sources that specifically incorporate habitat and biodiversity include:

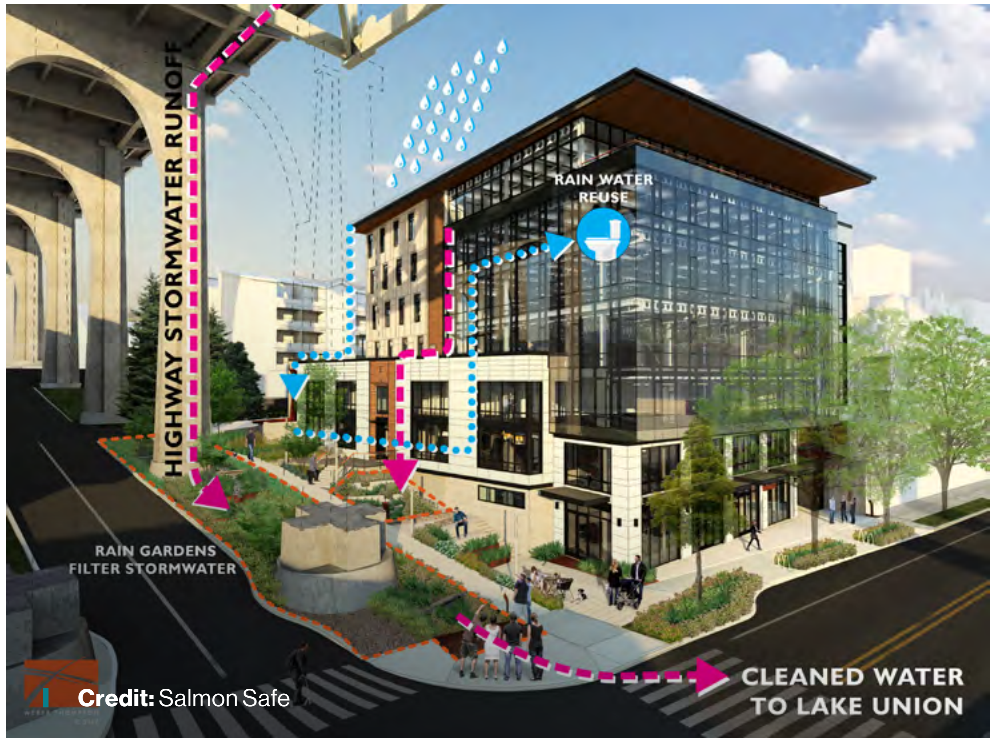
- The **National Science Foundation** offers an Environmental Sustainability grant through its Environmental Engineering and Sustainability cluster. The goal of the grant program is to "promote sustainable engineered systems that support human well-being and that are also compatible with sustaining natural systems." The grant opportunity specifically identifies "innovations in management of storm water … to support sustainability" as a research area. This opportunity should be perused in partnership with a local academic institution, as it requires the involvement of engineering research students. The most recent round of funding program has over $7 million available and anticipates granting over 100 awards.
- The **National Fish and Wildlife Foundation (NFWF)** provides financial assistance to habitat restoration and stormwater management through the Five Star and Urban Waters Restoration Program. Since 1999, the program has provided over $14 million in federal funding and $12 million in private and corporate funding for projections across the U.S. The program provides challenge grants, technical support, and opportunities for information exchange to enable community-based restoration projects. NFWF has also offered grants in the past for projects that improve habitat for monarch butterflies and other pollinators.
- The **National Oceanic and Atmospheric Administration (NOAA)** awarded $82 million in 2022 through its Transformational Habitat Restoration and Coastal Resilience Grants program, funded by the Bipartisan Infrastructure Law. Open to local governments as well as their non-profit partner organizations, these grants prioritize projects like GSI that use natural infrastructure to reduce damage from flooding and storms, promote resilient ecosystems and communities, and yield socioeconomic benefits.
- Projects that include trees as a GSI strategy can contact the **United States Forest Service**'s Urban and Community Forestry Program. The program is a "technical, financial, and educational assistance program, delivering nature-based solutions to ensure a resilient and equitable tree canopy" and invests directly in communities.
- The **Bureau of Reclamation's WaterSMART program** has a category of funding for Environmental Water Resources Projects. Eligible projects include "infrastructure improvements to benefit ecological values or watershed health." The program offers awards up to $3 million and projects must be completed within 3 years. This funding opportunity does require cost share contributions. States, tribes, irrigation districts, water districts, and state, regional, or local authorities in the Western United States or U.S. Territories, including Alaska, Hawaii, and Puerto Rico, are eligible.

Credit: Zoe van Duivenbode/TNC

5.2 State funding

Funding may also be available through state agencies that provide support for habitat restoration or enhancement projects. Several federal funding programs are delegated to state governments, which then match and administer grant and loan programs, or some States may have their own revenue streams for funding opportunities. Many of these programs are run through state agencies that may be non-traditional funders for municipal stormwater programs, including departments of wildlife, conservation, or natural resources. Although opportunities will vary state-to-state, some example programs include:

- A range of Community Conservation Funding Programs administered by the Missouri Department of Conservation, which in particular provides financial support for projects that incorporate conservation and recreation benefits.
- Chesapeake Bay related funding opportunities created by the Maryland Department of Natural Resources, including those offered through the Chesapeake and Coastal Grants Gateway.



Private Sector Partnership to Improve Salmon Habitat in Seattle through GSI Implementation

Water quality tests found toxic levels of Total Suspended Solids in the stormwater running off bridges that span lakes around Seattle. These lakes are critical habitat for the Coho salmon population, a keystone species for the Northwest United States. Recognizing the importance of clean water for salmon, Mark Grey, a Seattle-based developer, created a partnership to incorporate GSI in one of his developments under the Aurora bridge. The project diverts the polluted runoff from the highway into swales and rain gardens engineered to filter the stormwater. The partnership included the engineering firm KPFF; architects at Weber Thompson; and non-profits including The Nature Conservancy, Salmon Safe, Clean Lake Union, and Stewardship Partners. The project also received financial support from Boeing. Seattle Department of Transportation and Seattle Public Utilities also offered support to help navigate the permitting process. In addition to filtering stormwater, the project created additional green space for the neighborhood. Given the Aurora Bridge project's success, the team has also expanded GSI practices to other bridges over Lake Washington.

Sources: Salmon Safe (2023), Kett, H. (2017)

- The Vermont Fish and Wildlife Department's Vermont Watershed Program, which supports conservation, recreation, or projects leading to the enhancement of fish and wildlife habitats, water quality restoration, or phosphorus loading reduction.
- State programs focused on particular wildlife habitat needs, such as salmon habitat improvement funding offered through the Washington Fish and Wildlife by the Green/ Duwamish and Central Puget Sound Watershed Resource Inventory Area. The U.S. Fish and Wildlife Service provides funding to states, which then administer grant programs with federal and matching state funding. More information about these programs can be found on USFWS's State Wildlife Grants webpage.

5.3 Philanthropic foundations and non-profit organizations

Often overlooked by municipal agencies, private philanthropic foundations provide a significant amount of funding for environmental and community health improvement projects. Typically accessed by non-profit organizations, in many cases these grants are also open to public agencies or to partnerships between NGOs and public agencies. Foundations that provide support for habitat improvement projects range from large, national funders through local community foundations to foundations established by corporations as a vehicle for charitable giving.

A recent example of the latter category is the collaboration between Toyota Motors North American and the National Environmental Education Foundation to sponsor a Biodiversity Conservation Grant program focusing on enhancing pollinator habitats. While stormwater staff may not immediately think of pollinator habitat as an attribute of GSI, the habitat and wildlife benefits of nature-based stormwater infrastructure projects can be leveraged to access grant programs focused on creating these benefits.

Private companies and non-profit organizations may also adopt or sponsor GSI efforts like Philadelphia's GSI Partners initiative or the Trust for Public Land's Community Schoolyards projects. Local foundations also often offer support for GSI projects that offer co-benefits. These grants will not likely cover the full cost of implementing a GSI project but may complement other funding sources to cover costs associated with native plant selection and community engagement and education. The Council on Foundations has a community foundation locator tool that maps all accredited community foundations in the U.S.

5.4 Partnership opportunities

As with many other GSI co-benefits, the design of GSI to support urban habitat requires multi-disciplinary action. In a 2019 summit, the Urban Wildlife Information Network (UWIN) Summit identified disciplinary silos as the number one barrier to advancing wildlife-inclusive planning and design in urban areas.[60]

Transdisciplinary teams are key for ensuring that projects within the urban landscape meet multiple objectives. These efforts need not be extensively formal - starting small by consulting with groups that can provide knowledge on appropriate site-level design is a good first step (as described in the Minnesota Bee Squad Program earlier in this document). Consider partnering with city or regional wildlife and biodiversity management efforts to identify priority areas and target species and/or to incorporate GSI installations into ongoing monitoring efforts.

Partnerships with other entities may also provide unique implementation and/or funding opportunities. Academic institutions can offer local expertise and research resources including students. Local botanic gardens, museums, non-profits, and watershed groups would also be strong partners, as they would offer local experience, community recognition, and the potential for additional funding. The benefits associated with urban habitat and biodiversity also resonate with the private sector and local residents and can help further calls to action. The two case studies in this section highlight examples of partnerships that have leveraged expertise and funding from public and private sectors and non-profit organizations to implement GSI installations that directly benefit local wildlife.

6 Conclusion

Credit: Courtney Baxter/TNC

CONCLUSION

GSI projects offer an exciting opportunity to help communities expand their green footprint and improve the biodiversity and connectivity of urban habitats.

They also create circumstances for innovative partnerships and community involvement, which helps raise awareness about the importance of GSI projects and opens the door to a wider diversity of funding opportunities.

The understanding and incorporation of habitat considerations into GSI projects seems to be increasing but there are still opportunities to better document benefits. For example, it would be beneficial to have additional ecological studies with adequate replication and controls, or of sufficient duration, to explore the ability of green roofs to mimic the role of ground-level habitats in providing habitat benefits.[61,62] More information is also needed on the correlation between project size and benefits and the extent and heterogeneity of overall green networks.[63] The need for more substantiated research on the habitat benefits of GSI projects provides a particular opportunity for partnering with local academic institutions that can gather and analyze data.

Despite these research gaps, there is enough anecdotal evidence that GSI projects can support habitat diversity in addition to offering a host of secondary social and ecological benefits. Considering project location and design can maximize project benefits and create award-winning designs.

Credit: Patrick Doran/TNC

Credit: National Wildlife Federation

NWF's Sacred Grounds Program Partners with Congregations to Improve Habitat and Manage Stormwater in the Great Lakes

Through its Sacred Grounds project, the National Wildlife Federation (NWF) works with congregations to plan and install native plant habitats on the grounds of their church, synagogue, mosque, or other spiritual center. With technical and program assistance from NWF Great Lakes staff, 20 congregations in Toledo and a growing number in Grand Rapids and Detroit (as of April 2021) are creating beautiful spaces where both people and wildlife can thrive. And in the process, linking their faith practice with environmental stewardship and building community connections beyond their own membership.

Sacred Grounds builds on NFWF's Certified Wildlife Habitat program, through which nearly 800 places of worship have developed rain gardens, pollinator gardens, and outdoor spaces for meditation and education. The National Wildlife Federation works to establish authentic partnerships in each city, recognizing that while all ground is sacred, each community has unique challenges and opportunities. In Detroit, for example, faith-based institutions face stormwater fees based on impervious area. In order to lessen increases in monthly bills, many houses of worship across the city are increasingly interested in GSI projects but often lack funds and resources to get started.

Source: Holland (2021)

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